APPLICATION FOR PATENT

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Title: Toothbrush With Longitudinal To Lateral Motion Conversion

This is a Continuation-In-Part of pending Application No. 10/230,206 filed August 29, 2002, which is itself a Continuation-In-Part of Application No. 09/618,465 filed July 18, 2000, now issued as US Patent No. 6,477,729.

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to toothbrushes and, in particular, it concerns a toothbrush with longitudinal to lateral motion conversion.

It is known that best results are achieved by brushing teeth with an upwards and downwards action, thereby helping to remove food material stuck in the cracks between adjacent teeth. In practice, however, only a small proportion of users actually take the trouble to perform such a brushing action. Instead, most users revert to the much easier, but less effective, side-to-side brushing action.

In power-driven toothbrushes, this problem is commonly addressed by causing vibration or rotation of brush elements perpendicular to the handle (which is generally parallel to the side-to-side primary direction of motion). Examples of power-driven toothbrushes which employ such an action may be found in U.S. Patents Nos. 2,583,886 to Schlegel, 2,665,675 to Grover, and 5,864,911 to Arnoux et al.

In the field of manual toothbrushes, however, the problem is not so readily solved. A wide variety of toothbrush structures have been proposed in

an attempt to produce a secondary up-down motion even when the user only actively moves the toothbrush in a side-to-side primary direction of motion. Many of these employ rotatable bristle-carrying elements deployed so as to rotate about an axis perpendicular to the primary direction of motion. Examples of such structures may be found in U.S. Patents Nos. 5,142,724 to Park, 5,186,627 to Amit et al., and 5,996,157 to Smith et al. An alternative approach is suggested in U.S. Patent No. 1,643,217 to Lazarus, where a spiral arrangement of bristles extends along a rotatable shaft rotatably mounted parallel to the primary direction of motion. None of these proposed structures, however, has been found particularly effective.

Co-assigned U.S. Patent No. 6,477,729 from which this application indirectly takes priority discloses a toothbrush structure in which bristle wheels are deployed with their axes at an angle to the direction of motion so that rotation generated by motion of the toothbrush in contact with the teeth generates a component of brushing motion transverse to the direction of motion. The principle of operation of this structure is illustrated in Figure 8 where the primary brushing motion is assumed to be parallel to an axis defined by the length of the toothbrush handle and one or more brush element is configured to define a direction of bristle freedom of motion at an angle between about 15° and 75° to the axis. This structure is highly advantageous in that it very effectively converts side-to-side motion into an up-down brushing effect. It would be considered advantageous, however, to provide a similar effect without requiring the somewhat unusual bristle wheels proposed therein,

thereby allowing the toothbrush to maintain a "look" and "feel" more similar to a conventional tufted toothbrush.

U.S. Patents Nos. 5,398,366 and 5,269,038 to Bradley, and U.S. Patent No. 5,481,775 to Gentile et al., disclose a number of toothbrush designs which attempt to implement a similar concept of longitudinal-to-lateral movement conversion. In each case of the Bradley patents, the toothbrush bristles are subdivided between four rectangular brush elements each of which is restrained so as to perform a rocking or sliding motion at an angle inclined with respect to the length of the handle. In the embodiment of the '038 patent and two of the embodiments of the '366 patent, each brush element is hinged or rotatably connected to the toothbrush head so as to perform a rocking motion. In a third embodiment in the '366 patent, each brush element performs an angled sliding motion. In the Gentile et al. patent, the entire brush assembly is cylindrical and moves along slots defining a helical path.

Although the toothbrush structures of Bradley and Gentile et al. are based on a concept similar to that of the aforementioned US 6,477,729, the proposed structures are of very limited efficacy in practice. Specifically, in all of the implementations of Bradley using a rocking motion, the rectangular brush elements can only rock if the regions far from the axis of rotation perform primarily a up-down motion towards and away from the surface of the teeth. As a result, the contact of the brush element with the surface of the teeth effectively prevents significant rocking motion. Furthermore, even in the case of the sliding motion embodiment of Bradley and the helical motion

embodiment of Gentile et al., any longitudinal-to-lateral motion conversion occurs only once per stroke immediately after reversal of the direction of motion.

The latter problem is illustrated clearly in Figures 1A-1C which shows schematically a single brush element **100** corresponding to one of the four elements of Bradley or the single element of Gentile et al. It will be noted that the head of a conventional toothbrush typically includes a region of at least about 3 cm length provided with bristles. Thus, the Bradley references clearly refer to brush elements of length 1.5 cm or greater. During motion of the brush element along a row of teeth **24** as illustrated, the bristles **102** of each brush element are continuously in contact with at least one, and typically two, teeth at all times. Although individual bristles **(102')** may instantaneously be released from contact, the brush element **100** as a whole is subject to continuous frictional contact with the teeth as it moves. As a result, once the brush element has reached one extreme of its rocking or sliding motion near the beginning of each stroke, it remains lodged at the extreme of the range of motion for the remainder of each brushing stroke and fails to generate any transverse brushing motion, instead brushing parallel to the direction of movement like any a conventional toothbrush.

There is therefore a need for a toothbrush with longitudinal to lateral motion conversion which would allow groups of bristles to perform repeated longitudinal-to-lateral motion conversion during each brush stroke along the teeth.

SUMMARY OF THE INVENTION

The present invention is a toothbrush with longitudinal to lateral motion conversion.

According to the teachings of the present invention there is provided, a toothbrush comprising: (a) a toothbrush head attached to, or integrally formed with, an elongated handle, a direction of elongation of the handle being referred to as an axis; and (b) a plurality of brush elements associated with the toothbrush head, each of the brush elements including at least one tuft of bristles, a dimension of each of the brush elements parallel to the axis being no more than about 5 mm, wherein each of the brush elements assumes a released state projecting substantially upright from the toothbrush head, and wherein each of the brush elements is associated with a motion delineating configuration which defines a preferred direction of deflection of at least part of the brush element, the preferred direction of deflection being substantially perpendicular to a bristle extension direction and at an angle of between about 15° and about 75° to the axis.

According to a further feature of the present invention, the dimension of each of the brush elements parallel to the axis is no more than about 3 mm.

According to a further feature of the present invention, each of the brush elements includes exactly one tuft of bristles.

According to a further feature of the present invention, the preferred direction of deflection is at an angle of between about 30° and about 60° to the axis, and most preferably, between about 40° and about 50° to the axis.

According to a further feature of the present invention, the motion delineating configuration includes a flexible shaft portion of each of the brush elements, the shaft portion being constructed so as to exhibit a preferred direction of flexing corresponding to the preferred direction of deflection.

According to a further feature of the present invention, the flexible shaft portion has a cross-sectional shape with a major dimension and a minor dimension, the minor dimension being no more than two thirds of the major dimension so as to define the preferred direction of flexing.

According to a further feature of the present invention, the motion delineating configuration includes a hinge arrangement defining an arcuate path of at least part of the brush element.

According to a further feature of the present invention, the hinge arrangement includes a hinge formed as part of the brush element.

According to a further feature of the present invention, the hinge arrangement includes a hinge formed between the brush element and the toothbrush head.

According to a further feature of the present invention, the hinge arrangement includes a substantially cylindrical pin element inserted into a complementary socket.

According to a further feature of the present invention, the motion delineating configuration includes an elongated slot associated with the toothbrush head for limiting movement of the brush element to a predefined direction.

According to a further feature of the present invention, the motion delineating configuration includes an elongated slot formed in the toothbrush head within which the brush element is slidably mounted.

According to a further feature of the present invention, the motion delineating configuration includes a resilient element deployed to bias the brush element to return to the released state.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIGS. 1A-1C are schematic illustrations of a sequence of positions during brushing of the teeth of a user with a toothbrush according to the teachings of U.S. Patent No. 5,269,038 to Bradley;

FIGS. 2A-2C are schematic illustrations of a sequence of positions during brushing of the teeth of a user with a toothbrush constructed and operative according to the teachings of the present invention;

FIG. 3 is a schematic isometric view of the head of a toothbrush illustrating multiple options for implementations of a brush element according to the teachings of the present invention;

FIG. 4 is a side view showing the structure of the brush elements for each implementation illustrated in Figure 3;

FIGS. 5A and 5B are schematic isometric views of two implementations of a dirt cover for use with certain brush elements from Figure 3;

FIG. 6 is a schematic isometric view of a hinge pin structure for use in certain brush element implementations of Figure 3;

FIGS. 7A and 7B are schematic plan views of the toothbrush of Figures 2A-2C showing two exemplary deployments of brush elements according to the teachings of the present invention; and

FIG. 8 is a schematic illustration of the geometrical relationship between direction of toothbrush movement and preferred direction of brush element deflection which underlies operation of the present invention and the related prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a toothbrush with longitudinal to lateral motion conversion.

The principles and operation of toothbrushes according to the present invention may be better understood with reference to the drawings and the accompanying description.

Referring now to the drawings, Figures 2A-2C illustrate the operation of a toothbrush, generally designated **10**, constructed and operative according to the teachings of the present invention. Generally speaking, toothbrush **10** includes a toothbrush head **12** attached to, or integrally formed with, an elongated handle **14**. Toothbrush head **12** supports a plurality of brush elements **16** each including at least one tuft of bristles **18**. Each brush element **16** assumes a released state **20** projecting substantially upright from the toothbrush

head, and can be deflected, independent of the other brush elements, in a preferred direction of deflection (e.g. to position **22**), the direction being substantially perpendicular to a bristle extension direction and at an angle of between about 15° and about 75° to an axis **15** defined by a direction of elongation of handle **14**, thereby providing longitudinal-to-lateral motion conversion according to the principle illustrated in Figure 8 described above. Various examples of motion delineating configurations for defining the preferred direction of deflection will be discussed below with reference to Figures 3 and 4.

It is a particular feature of the present invention, in contrast to the devices of the aforementioned prior art, that a dimension of each brush element **16** parallel to the axis is no more than about 5 mm. In an alternative, but not necessarily identical, approach to defining this feature, it is a particular feature that each brush element has not more than three tufts of bristles **18** arrayed along the dimension parallel to the axis. This feature, as defined by either or both of these criteria, tends to ensure that each individual brush element **16** clears a tooth **24** and is allowed to return from deflected position **22** to its upright position **20** before encountering the next tooth **24**, thereby allowing each brush element to perform repeated longitudinal-to-lateral motion conversion cycles within each stroke of toothbrush **10**. This motion conversion, supplementing the motion conversion which occurs each time the user changes direction between strokes, greatly improves the overall efficacy of the motion conversion, and hence of the overall brushing motion.

Before proceeding further with the description of the present invention, it will be useful to define certain terminology as used herein in the description and claims. Firstly, when reference is made to a dimension of the brush elements **16** parallel to the axis, the intention is to refer to the length parallel to the axis of the portion of the brush element which is configured to contact the teeth. Similarly, the measurement is made when the brush element is upright and the bristles not flexed. Clearly, the deflection of the brush element and flexing of the bristles may produce temporary elongation in the direction parallel to the axis.

In a further matter of terminology, reference is made to deflection of the brush elements in a "preferred direction of deflection". It should be appreciated that the deflection of the present invention may be a bending motion, a pivotal motion, a linear or curved sliding motion, or any other form of motion where at least a distal portion of the brush element (i.e., furthest from its point of association with the toothbrush head) moves in the correspondingly defined direction. Where the motion is not linear, the preferred direction of motion is taken to be the tangent to the direction followed by the distal portion of the brush element during the initial motion from the "released state". The "direction" is typically, although not necessarily, a line of motion extending symmetrically in two opposite directions from the "released state" position.

When defining the geometrical features of the present invention, reference is made to an axis defined by "the extensional direction of the toothbrush handle". Conceptually, it is the geometry with respect to the

direction of motion which is essential to proper operation of the present invention. The extensional direction of the handle is chosen as a structural feature which is related to the direction of motion. However, it will be noted that toothbrush handles are often designed to be non-parallel to the head of the toothbrush. For this reason, reference is made to an "axis" defined by the handle configuration. This direction would ideally be defined as the projection of the extensional direction of the handle onto a plane of contact with the teeth. This geometrical construct corresponds to the direction of motion which will be performed by a typical user performing a side-to-side type brushing action. For most purposes, an axis passing along the length of the toothbrush handle is sufficient for evaluating the geometrical definitions of the features of the present invention.

With regard to the term "bristles", this is used herein generically to refer to any and all fibers suited for use in toothbrushes, including natural and synthetic bristles.

Turning now to the features of the present invention in more detail, as mentioned before, according to a first way of defining the present invention, the dimension of each brush element **16** parallel to the axis, i.e., the "length" of the brush element, is no more than about 5 mm. Preferably, the dimension of each brush element **16** parallel to the axis is no more than about 3 mm, and most preferably less than 2 mm. These shorter elements are most likely to return to their upright position between adjacent teeth, thereby optimizing the longitudinal-to-lateral motion conversion so that it occurs repeatedly along the

length of each stroke and not just immediately after reversal of the stroke direction. It should be noted that the dimension of the brush elements **16** transverse to the axis, i.e., the "width" of the brush elements as measured into the page as viewed in Figures 2A-2C, is typically less critical to the present invention, since an increased width does not necessarily interfere with the righting of the brush elements between teeth. Thus, the width may be less than, equal to, or greater than, the length of the brush element **16**. In a most preferred implementation, the width and length are substantially equal.

As mentioned earlier, the length of the brush elements may alternatively be delimited in terms of numbers of tufts of bristles arrayed along a direction parallel to the axis. A maximum number according to this manner of defining the invention is typically three tufts, and more preferably two tufts. Here too, the limitation is specifically in the direction parallel to the axis, and each brush assembly may in fact support rows of staggered tufts of bristles. Thus, an element with three tufts arrayed along the axial direction may correspond to as many as five or six staggered interspaced laterally-extending rows of tufts. In preferred implementations, the number of tufts arrayed laterally is substantially the same as the number deployed along the length. In one particularly preferred implementation used herein to exemplify the present invention, each brush element **16** carries includes exactly one tuft of bristles **18**. In this case, the brush element **16** is typically implemented as a stem or shaft within which the bristle tuft is mounted.

As mentioned earlier, each brush assembly is associated with a motion delineating configuration for defining a preferred direction of deflection substantially perpendicular to a bristle extension direction and at an angle of between about 15° and about 75° to the axis. More preferably, the preferred direction of deflection is at an angle of between about 30° and about 60°, and most preferably, between about 40° and about 50°, to the axis. Various examples of motion delineating configurations suitable for implementing the present invention will now be described with reference to Figures 3 and 4.

Turning now to Figures 3 and 4, there is shown an assortment of different preferred implementations for brush element **16** and the corresponding motion delineating configuration. For the purpose of concise presentation of these different options, they are shown schematically in Figure 3 in the context of a toothbrush head **12**. It will be understood that, in a practical implementation, a given toothbrush will typically be implemented using a single structural implementation for all brush elements **16**, and that the brush elements will be arrayed over substantially the entire area of toothbrush head **12** with preferred directions of deflection on symmetrically distributed on both sides of the axial direction.

Turning now to a first preferred implementation of brush element, designated ***16a***, the motion delineating configuration is here implemented using a flexible shaft portion **30** which is constructed to as to inherently exhibit a preferred direction of flexing. This may be achieved by using suitably oriented materials with structurally non-isotropic properties, or by structural/mechanical

design which defines a direction of minimum resistance to flexing. In the example illustrated here, flexible shaft portion **30** has a cross-sectional shape with a major dimension and a minor dimension, the minor dimension being no more than two thirds, and preferably less than half, of the major dimension so as to define the preferred direction of deflection. Such a structure is sometimes referred to as an "integral hinge" and may readily be implemented using various standard polymer production techniques. Optionally, the thinning of the "minor dimension" of flexible portion **30** may be less pronounced than is shown here, and may be spread over a longer section of the shaft to offer increased mechanical strength with a diffuse flexing motion rather than a well defined "hinge".

In a second preferred implementation of brush element, designated ***16b***, a flexible shaft portion **32** is flexible equally in all directions and the motion delineating configuration includes an elongated slot associated with the toothbrush head for limiting movement of the brush element to a predefined direction. In the case shown here, shaft portion **32** is sunken in to a shaped socket **34** in toothbrush head **12** and side-walls of socket **34** and/or edges around the top of socket **34** define the elongated slot **36**. Clearly, an equivalent function could be provided without shaped sockets **34** by use of a slotted structure overlying toothbrush head **12**.

In a third preferred implementation of brush element, designated ***16c***, an enlarged base portion **38** of brush element ***16c*** is slidably mounted within an elongated slot **40** formed in the toothbrush head. In contrast to the arcuate

motion provided by the other implementations of Figures 3 and 4, the motion of brush element **16*c*** is a linear reciprocating motion.

The remaining preferred exemplary implementations of the brush element shown in Figures 3 and 4 all employ a motion delineating configuration including a hinge arrangement defining an arcuate path of at least part of the brush element relative to the toothbrush head **12**. In the cases of brush elements **16*d***, **16*e*** and **16*f***, the hinge arrangement includes a hinge formed as part of the brush element, whereas in brush elements **16*g***, **16*h*** and **16*i***, the hinge arrangement includes a hinge formed between the brush element and toothbrush head **12**. In each case, the hinge arrangement preferably includes a substantially cylindrical pin element inserted into a complementary socket.

Referring briefly to the details of each example, brush element **16*d*** has a base portion **42** formed with hinge pin portions **44** projecting from both sides, and a pair of hinge brackets **46** associated with an upper portion of brush element **16*d*** configured for engagement over pin portions **44**. Brush element **16*f*** is a similar structure where base portion **42** terminates in a cylindrical pin **48** at its upper end, and the upper portion of the brush element features a complementary resilient C-shaped clip **50** configured to snap into engagement with pin **48**. Brush element **16*e*** is similar to **16*f*** but with the pin and clip reversed so that base portion **42** features the clip **50** and the upper portion features pin **48**. In all three cases **16*d***, **16*e*** and **16*f*** the hinge configurations are provided with abutment surfaces on each side of the hinge to delimit a

maximum range of angular deflection, preferably chosen to be no more than ±40° from the upright position, and most preferably no more than ±30°.

Turning now to brush elements **16*g***, **16*h*** and **16*i***, as mentioned above, these employ a hinge formed between the brush element and toothbrush head **12**. In the case of **16*g***, a transverse bore **52** in the rounded base of the brush element receives partially-cylindrical projections from each side of a shaped socket **54**. In the case of **16*h***, this configuration is reversed with a cylindrical pin **56** formed at the base of the brush element snap-fitting into a correspondingly shaped socket **58**. In the case of **16*i***, engagement between snap-fitting pin projections and a socket **60** occurs near the top edge of an inwardly opening cavity **62** within which the countersunk brush element base **64** moves. This latter configuration ensures a small opening around the exposed part of the brush element while the countersunk base **64** of the brush element moving within the shaped cavity **62** provides structural support against torque applied other than in the predefined direction of motion or beyond the intended range of motion.

Referring briefly to Figures 5A and 5B, these show two cover elements which are considered useful in certain implementations for limiting ingress of dirt into a socket in toothbrush head **12** around the base of the brush elements. The round cover of Figure 5A is used where the socket opening is localized, such as in brush element **16*i***. In implementations with an open slot, the elongated cover of Figure 5B is preferred. According to an additional, or alternative, feature, any sockets formed within toothbrush head **12** may have

drainage channels open to the rear of the head to facilitate though-flow of water for flushing-out toothpaste or dirt caught in the socket.

Referring briefly to Figure 6, this illustrates a possible hinge-pin structure, in this case suited to the implementation of brush element ***16i*** from Figures 3 and 4. Clearly, by providing shaped sockets for the pin projections to engage, a well-defined pivotal hinge structure is generated. Details of the implementations of the various other hinge structures shown schematically above will be self-explanatory to one ordinarily skilled in the art by analogy to this example.

It will be noted that the repeated longitudinal-to-lateral motion conversion performed by each brush element during a single unidirectional stroke of the toothbrush is dependent upon the brush element returning at least part of the way from its deflected state towards its upright state when released. In many cases, the natural spring-back effect of bristles being momentarily released from contact with a tooth carries sufficient momentum to flick the brush element away from its extreme deflected position towards the upright position. Preferably, however, in order to enhance operation, the motion delineating configuration includes a resilient element deployed to bias the brush element to return to the upright released state. In the examples of brush elements ***16a*** and ***16b*** described above, this is typically an inherent property of the flexible shafts **30** and **32**. In other implementations, a similar effect is achieved by addition of a spring-like element (not shown), typically implemented as one or more leaf-spring element integrally molded with a

plastic portion of the brush element base, as is known in the art of molded plastic articles.

Parenthetically, it should be noted that the motion delineating configurations of the present invention define at least one preferred direction of deflection and may, in certain cases, define more than one preferred direction of deflection for a brush element. Thus, for example, in the case of brush element **16*b***, or **16*h*** implemented with a ball-and-socket joint, an X-shaped slot may be used to define two alternative preferred directions of deflection, each at the required angle to the axis, between which the brush element can switch freely. In an alternative implementation, the stem of the brush element itself may be implemented so as to provide two preferred flexing direction, such as by use of a flexible stem portion with an X-shaped cross-section which inherently offers resistance to flexing in the planes of the X-walls while allowing flexing in the intermediate directions more easily.

Finally, turning to Figures 7A and 7B, it will be noted that a toothbrush head **12** typically carries at least about 10 brush elements **16**, and more typically between 20 and 50 such brush elements. Preferably, roughly equal numbers of brush elements **16** have preferred directions of deflection on each side of the axis defined by handle **14**, e.g. ±45° thereto, so as to avoid generating a net lateral force which would tend to deflect the entire toothbrush from the course intended by the user. The brush elements **16** may be deployed in any desired distribution, covering the entire available area of toothbrush head, or combined with other brush elements such as conventional fixed bristle

tufts. For maximum brush density, it is particularly advantageous to arrange the brush elements in partially interleaved staggered rows of alternating directions of deflection. By way of example, Figure 7A illustrates a first preferred arrangement where brush elements **16**, represented by double-ended arrows indicating their directions of deflection, are deployed in rows transverse to the toothbrush head with alternate rows at ±45° to the axis. Figure 7B shows a further example where rows of similar brush elements are deployed substantially parallel to the axis, again with adjacent rows having deflection directions rotated relative to the axis in alternating senses. In both cases, at least three are preferably used, and more preferably at least four.

It will be appreciated that the above descriptions are intended only to serve as examples, and that many other embodiments are possible within the scope of the present invention as defined in the appended claims.